Proposed State Route 125 South Air Emissions and the Sweetwater Reservoir: A Review of Recent Reports Sponsored by the Sweetwater Authority

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ES.2 BACKGROUND OF STATE ROUTE 125 AND THE SWEETWATER RESERVOIR

A new north-south highway, named State Route 125 South (SR 125), is planned for the San Diego region. Scheduled to open in the year 2002, SR 125 South will be an 11.2-mile highway connecting the Otay Mesa Port of Entry with the San Diego regional highway network (connecting SR 54 at its northern terminus to SR 905 at its southern terminus). The highway was originally proposed in the early 1960s and was added to the San Diego area's Regional Transportation Plan in 1984. The project plan calls for a privately financed toll road, starting as a four-lane highway in the year 2002, and expanding to an eight-lane highway by the year 2015. A short portion, approximately 1½ miles, of SR 125's 11-mile length will pass adjacent to the Sweetwater Reservoir. For most of this short portion, SR 125 will be located approximately 200 to 600 meters downstream from the reservoir (Stoll, 1999; California Department of Transportation, 1999).

ES.3 OBJECTIVE OF THIS REPORT

The California Department of Transportation (Caltrans) asked scientists at U.C. Davis (UCD) to review the relationship between proposed SR 125 (including an associated extension of SR 54) and its potential impact on water quality at the Sweetwater Reservoir. Specifically, Caltrans asked UCD to review and comment on two recent studies: "SR 125 South Route Alternatives: Potential Air Emissions Impact on Sweetwater Reservoir (Ogden, 1997a and 1997b)," and "The Impact of SR 125 Vehicle Emissions on the Sweetwater Reservoir, Transport, Environmental Fate, and Cancer Risk Assessment (Byard and Giroux, 1999)." As part of that review, UCD examined health risk estimates in the Sweetwater Authority-sponsored studies that estimated the relationship between SR 125-generated air pollution and health risks to reservoir water users.

ES.4 KEY PROBLEMS WITH THE SWEETWATER AUTHORITY-SPONSORED REPORTS

Both Sweetwater Authority-sponsored studies use conservative, unrealistic assumptions as part of their screening analysis. The unrealistic results of the assumptions are evident from comparisons with existing air and water quality data. When more realistic assumptions are substituted for the most important unrealistic assumptions in each report, estimated health risks become negligible. Additionally, the risk assessment methodologies employed by the Sweetwater Authority-sponsored studies were flawed. Key problems include:

- The Sweetwater Authority-sponsored analyses neglected to evaluate the relative importance of regional-scale emissions from upwind portions of the San Diego metropolitan area. These existing background pollution sources are far more important than the emissions assumed to come from the new highway.
- The calculations used in the analyses violate conservation of mass principles. This problem applies to the analysis of air emissions moving from vehicles towards the reservoir; the problem relates to the assumed deposition velocity. For example, if deposition assumptions were consistently applied, estimated air concentrations over the reservoir would have been lower due to plume depletion occurring between the highway and the reservoir.
- The reports fail to properly estimate mass transfer at the air/water interface. An important example involves a well established chemical principle, called Henry's Law, which states that the equilibrium concentration of a volatile chemical in water is proportional to its vapor concentration in the atmosphere above the water. A volatile chemical will dissolve from the air into water only until this relationship is satisfied. The assumptions in the Sweetwater Authority-sponsored studies fail to account for this scientific principle and allow more of the pollutant to enter the water than is physically possible. The rate of deposition into the reservoir of fine particles emitted by vehicles is also unrealistically high. The result is an over-estimation of pollutant concentrations in the water body by several orders of magnitude.
- The reports use a variety of assumptions that are incorrect, are based on outdated information, or otherwise serve to overestimate predicted pollutant concentrations, exposure, and resulting health risks. These unrealistic assumptions range across numerous categories and affect the risk assessment at every major analytical point—from emissions estimation, to pollutant dispersion and deposition, to the transfer of pollutants from the reservoir to water users. The result is a gross overprediction in estimated health risks. As an example of these problems, one of the reports estimates more than three times the pollutant mass leaving the reservoir than entering the reservoir, a physical impossibility.

ES.5 FINDINGS

In summary, the most important UCD findings follow:

1. Based upon examination of the Sweetwater Authority's consultant reports and additional data collected by UCD, there are no significant health effects that would result from SR 125-generated air emissions depositing onto the Sweetwater Reservoir.
2. Both the Ogden report (especially the draft version, Ogden 1997a, as well as the final version, Ogden 1997b) and the Byard report (Byard and Giroux, 1999) include unrealistic assumptions that increase the estimated SR 125-related health risks to Sweetwater Reservoir drinking water users.

3. UCD briefly reviewed data from other reservoirs located near highways; the review did not identify any evidence that roadway-related air emissions degrade water quality.
4. Regional scale air emissions (i.e., emissions from the entire metropolitan region) already affect ambient air concentrations over the reservoir, and contribute hundreds of times more pollutant deposition onto the reservoir than the projected emissions from SR 125. Either there is an existing problem with water quality in the reservoir, or common sense indicates that no measurable problem will result in the future from SR 125.

ES.6 RECOMMENDATIONS

Given the relative importance of regional scale vs. SR 125 air emissions, the Sweetwater Authority should evaluate whether current regional air pollution contributes to water quality problems. Such an evaluation should consider, at a minimum, the total contribution of San Diego metropolitan area emissions to air pollutant concentrations observed over the reservoir, the resulting concentration of pollutants in the water body, the exposure of individuals to those pollutant concentrations, and the risk, if any, that results.

In addition, UCD recommends that a broader review of air pollution and drinking water be undertaken to determine what, if any, long-term research efforts ought to be conducted. Such research may be appropriately undertaken by a variety of public health and/or environmental management agencies.

1. INTRODUCTION AND SUMMARY

The California Department of Transportation (Caltrans) asked University of California, Davis (UCD)[1] scientists to evaluate whether air emissions from proposed State Route 125 South (SR 125), which will be located near the Sweetwater Reservoir, would generate adverse health risks to reservoir users. The Sweetwater Authority has been concerned that air pollution from vehicles using SR 125 will deposit onto the reservoir, contaminate the drinking water, and cause excess cancer risks to reservoir users. UCD reviewed the proposed project and its proximity to the reservoir and determined that emissions from SR 125 will have a negligible impact on health risk. This finding is contrary to that of two studies commissioned by the Sweetwater Authority. Both Sweetwater Authority-sponsored studies use conservative, unrealistic assumptions as part of their screening analysis. When more realistic assumptions are substituted for the most important unrealistic assumptions in each report, estimated health risks become negligible.

[1] The acronym UCD will be used for convenience to denote the individuals that contributed to the report. Its use does not imply, nor is it intended to imply, endorsement of the report's conclusions by the University of California.

2. OVERVIEW

2.1 BACKGROUND ON THE SR 125 PROJECT

A new north-south highway, named State Route 125 South (SR 125), is planned for the San Diego region. Scheduled to open in the year 2002, SR 125 South will be an 11.2-mile highway connecting the Otay Mesa Port of Entry with the San Diego regional highway network (connecting SR 54 at its northern terminus to SR 905 at its southern terminus). **Figures 2-1 and 2-2** illustrate the location of the proposed road. The highway project has been planned for many years to accommodate the San Diego region's population and employment growth. The highway was originally proposed in the early 1960s and was added to the San Diego area's Regional Transportation Plan in 1984. The project plan calls for a privately financed toll road, starting as a four-lane highway in the year 2002, and expanding to an eight-lane highway by the year 2015. The ultimate facility will consist of up to eight mixed flow lanes and a median wide enough to accommodate two high occupancy vehicle lanes or transit facilities. A short portion, approximately 1½ miles, of SR 125's 11-mile length will pass adjacent to the Sweetwater Reservoir. For most of this short portion, SR 125 will be located approximately 200 to 600 meters downstream from the Reservoir (Stoll, 1999; California Department of Transportation, 1999).

2.2 U.C. DAVIS REVIEW OF SR 125 AIR EMISSIONS AND POTENTIAL ADVERSE CONSEQUENCES FOR SWEETWATER RESERVOIR USERS

Caltrans asked scientists at UCD to review the relationship between proposed SR 125 and its potential water quality impacts at the Sweetwater Reservoir. As part of that review, UCD examined health risk estimates in Sweetwater Authority-sponsored studies that estimated the relationship between SR 125-generated air pollution and health risks to reservoir water users.

Specifically, Caltrans asked UCD to review and comment on two recent studies: "SR 125 South Route Alternatives: Potential Air Emissions Impact on Sweetwater Reservoir" (Ogden 1997a and 1997b), and "The Impact of SR 125 Vehicle Emissions on the Sweetwater Reservoir, Transport, Environmental Fate, and Cancer Risk Assessment" (Byard and Giroux, 1999). UCD faculty and staff have worked over the past two years to review and comment on these studies, and to share findings and recommendations with the report authors, the Sweetwater Authority, and with Caltrans. This report presents the major findings from these UCD reviews.

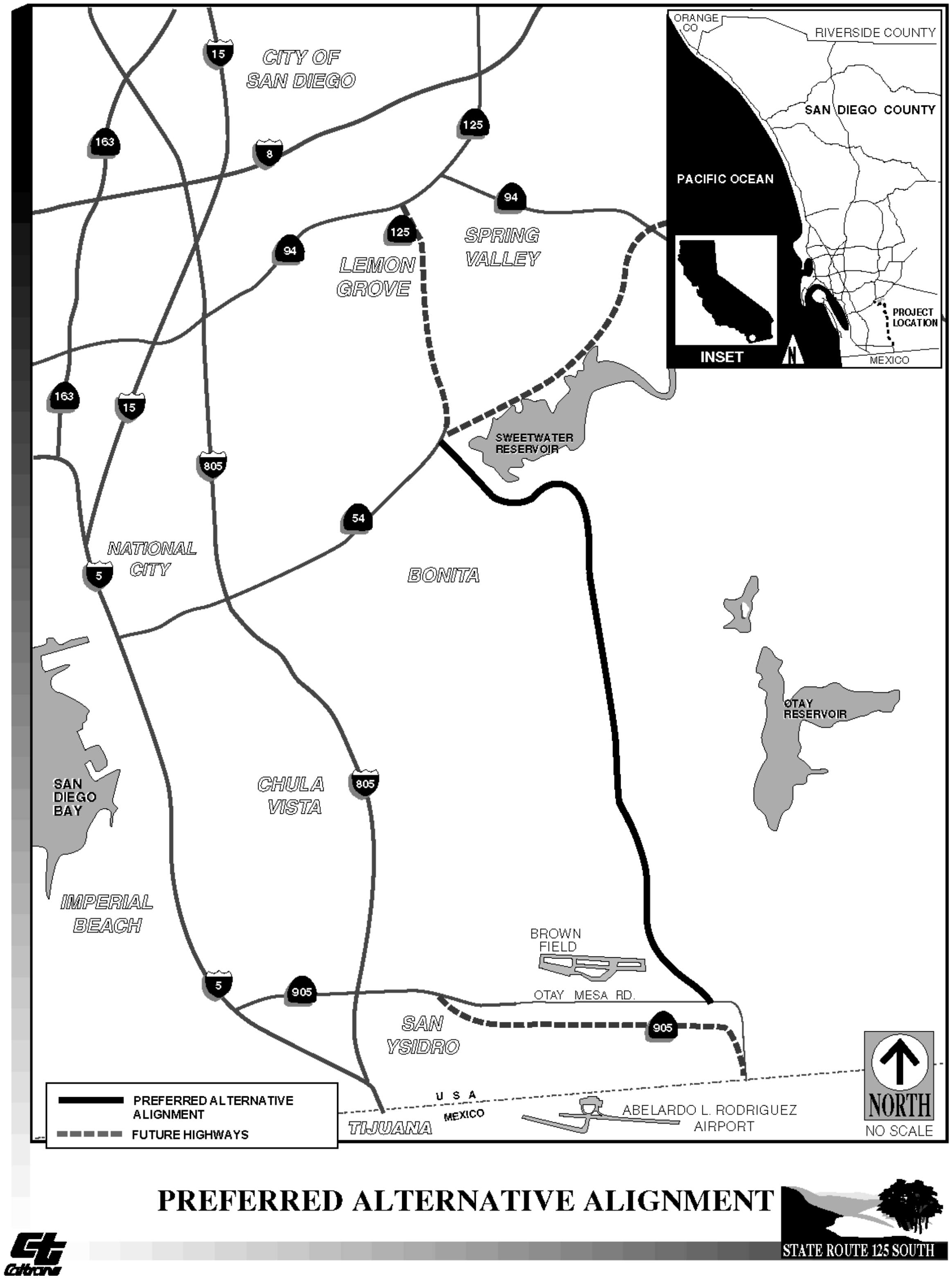

Figure 2-1. The SR-125 project in relation to the San Diego metropolitan area.

Figure 2-2. Aerial view of SR-125 in relation to the western edge of the Sweetwater Reservoir.

2.3 SUMMARY FINDINGS AND RECOMMENDATIONS

In summary, the most important UCD findings follow:

1. An examination of the Sweetwater Authority's consultants reports and additional data collected by scientists at UCD indicates that no significant health effects would result from SR 125-generated air emissions depositing onto the Sweetwater Reservoir.
2. Both the Ogden report (especially the draft version, Ogden, 1997a, as well as the final version, Ogden, 1997b) and the Byard report (Byard and Giroux, 1999) include unrealistic assumptions that increase the estimated SR 125-related health risks to Sweetwater Reservoir drinking water users.
3. UCD briefly reviewed data from other reservoirs located near highways; the review did not identify any evidence that roadway-related air emissions degrade water quality.
4. Regional scale air emissions (i.e., emissions from the entire metropolitan region) already affect ambient air concentrations over the reservoir and contribute far more pollutant deposition onto the reservoir than the projected emissions from SR 125 (even using the overly conservative assumptions in the Byard report). Either there is an existing problem with water quality in the reservoir, or common sense indicates that no measurable problem will result in the future from SR 125.
5. Given the relative importance of regional scale vs. SR 125 air emissions, Sweetwater Authority should evaluate whether current regional air pollution contributes to water quality problems. Such an evaluation should consider, at a minimum, the total contribution of San Diego metropolitan area emissions to air pollutant concentrations observed over the reservoir, the resulting concentration of pollutants in the water body, the exposure of individuals to those pollutant concentrations, and the risk, if any, that results.

2.4 A COMMENT ON SCREENING LEVEL ANALYSES VERSUS MORE COMPLETE RISK ASSESSMENTS

Both the Ogden and Byard studies present health risk information that contradicts UCD's analysis of health risks resulting from SR 125 air pollution impacts on the Sweetwater Reservoir. The explanation for this discrepancy lies in the assumptions made by the Ogden and Byard report authors. The Ogden and Byard reports can be characterized as a type of "screening level" analysis. Such analyses typically utilize conservative assumptions to quickly "screen" for potentially adverse health impacts. If, using conservative assumptions, no adverse risks are estimated, then analysts are generally comfortable concluding that the exposed populace is not at risk under real world conditions. Typically, if a screening analysis estimates an adverse impact, more refined analyses, with more realistic assumptions, are conducted to determine whether the health risk is a significant concern or simply an artifact of the assumptions used in the analyses. In the case of the Ogden and Byard reports, the health risk analyses used a number of unrealistic analytical assumptions and concluded by significantly over-estimating health risks. UCD found that estimated risks fell to negligible levels when these assumptions were replaced with more realistic information.

An important example of an overly conservative assumption in both the Byard and Ogden reports concerns the exchange of pollutants between water bodies and the air circulating above the water surface. There is a scientific principle, Henry's Law, which governs the partition of a chemical between its concentration in water and its corresponding vapor concentration in the atmosphere. Simply put, as the concentration of certain pollutants increases in water, their tendency to escape out of the water becomes greater and soon the amount that enters the water from the air equals the amount that leaves the water. The equilibrium concentration in the water is dependent upon, among other things, the atmospheric concentration of the pollutant. It is not physically reasonable to have more of a pollutant enter the water than its equilibrium concentration for a given airborne concentration. The assumptions in both the Ogden and Byard studies fail to account for this scientific principle and allow more of the pollutant to enter the water than is physically reasonable. The result is an over-estimation of pollutant concentrations in the water body. The revised Ogden report acknowledges the existence of Henry's Law but does not apply it. The Byard report does not acknowledge the effect of Henry's Law on limiting water concentrations. [2]

Screening analyses are an acceptable first approach to conducting health risk assessments. However, if the results of such analyses will be used to establish policy or provide the basis for significant and costly decision making, it is incumbent upon the analysts to revisit their work and correct unrealistic assumptions before using the results. UCD revisited key analysis steps in the Byard and Ogden studies, corrected for unrealistic assumptions, and found resulting health risks to be negligible.

2.5 REPORT ORGANIZATION

The remainder of this report covers the following material:

- Section 3 provides a conceptual discussion of how to analyze the relationships between sources of air pollutant emissions and drinking water quality at reservoirs.
- Section 4 summarizes UCD's comments on the Ogden study (draft and final reports).
- Section 5 summarizes UCD's comments on the Byard study.
- Section 6 provides additional observations related to other reservoirs, air quality regulations, and regulatory efforts to reduce mobile source-related toxic emissions.
- Section 7 summarizes the overall conclusions from UCD's reviews over the past two years.
- Section 8 lists recommendations for further research.

In addition, several appendices are included to provide additional information.

[2] A good overview discussion of the pollutant exchange between air and water is provided by the U.S. Environmental Protection Agency in their Second Report to Congress on "Deposition of Air Pollutants to the Great Waters" (U.S. Environmental Protection Agency, 1997; pp. 74-76).

3. CONCEPTUAL DISCUSSION: ANALYZING THE RELATIONSHIPS AMONG SOURCES OF AIR POLLUTANT EMISSIONS AND DRINKING WATER QUALITY AT RESERVOIRS

When assessing the impact of vehicular emissions over a broad area, such as a reservoir, the relative strength of the emission source in question must be weighed against the background pollution concentrations and the distance between the source in question and the receptor. San Diego's background pollution is created from the contribution of hundreds of thousands of upwind industrial, domestic and vehicular sources (e.g., combustion sources in Ocean Beach, Pacific Beach, Point Loma, San Diego, Mission Valley, National City, and vehicles on local roadways and highways such as Interstate-5, Interstate-805, Interstate-8). Because atmospheric dispersion combined with pollutant-specific reactivity rates quickly mix a roadway's emissions into the ambient air, concentrations decay rapidly as one moves further downwind from the road. Generally, after several hundred meters the emissions from a highway source blend into, and become indistinguishable from, the background pollutant levels.

One example of how regional emissions are more important than individual roadway emissions involves the pollutant benzene. The California Air Resources Board (ARB) currently measures average annual benzene concentrations at Chula Vista and El Cajon. Chula Vista is southwest of the Sweetwater Reservoir, and El Cajon is north of the reservoir. Averaged together, the monitored benzene concentrations from these two neighborhood-scale monitors provide an approximation of the general background conditions for the San Diego metropolitan area. The most recent data available (1997) documents benzene concentrations occurring today at these sites that are roughly 250 times larger than the SR 125-generated benzene concentrations that the Byard report projects will occur over the reservoir. Further, the Byard report assumes benzene emission rates based on vehicle data that pre-dates the California reformulated gasoline (RFG) program. Since RFG has lowered ambient benzene concentrations by about 50 percent, it can be shown that regional benzene emissions will be approximately 500 times more important than the Byard report's projected benzene emissions related to SR 125. Thus, if significant risks actually were to occur from SR 125, they must already exist at a much greater level in the reservoir now from ambient benzene alone. The Sweetwater Authority has not reported any data indicating that there is an existing problem from benzene in the water. Thus, future increases in concentration or corresponding risk from SR 125 would be immeasurable. If excess cancers such those as projected by the Byard report are in fact occurring, such a situation would call for significant assessment and mitigation of regional, as opposed to project-level, emissions. However, there is no evidence of significant benzene levels in the Sweetwater Reservoir, and this lack of evidence implies that the Byard analysis is faulty. Appendix A details the background information on benzene[3].

The most appropriate approach for analyzing air pollution impacts on the Sweetwater Reservoir is to look at regional air pollution, rather than air pollution from a single roadway. A

[3] It is worth noting that background ambient air benzene levels in San Diego are generally comparable to or lower than those measured elsewhere in the state. The health effects associated with these benzene levels would be expected to result from inhalation-based exposure, not through reservoir-issued drinking water that has been in contact with polluted air.

graphic illustration of that concept is presented in Appendix B. Appendix B includes two figures illustrating the relationship between regional carbon monoxide (CO) emissions and the Sweetwater Reservoir. Since CO is emitted almost entirely by motor vehicles, CO emissions serve as an excellent surrogate for motor vehicle emissions activity. The two figures demonstrate that Sweetwater Reservoir is downwind of most of the San Diego metropolitan area's vehicular emissions. The motor vehicle emissions contributed by SR 125 would be a negligible fraction of the region's overall motor vehicle emissions.

4. COMMENTS ON THE OGDEN STUDY

UCD research staff reviewed the February 1997 Sweetwater Authority report prepared by Ogden Environmental Services: "SR-125 South Route Alternatives: Potential Air Emissions Impact on Sweetwater Reservoir" (Ogden, 1997a). The February 1997 report examined 37 chemicals and/or groupings of chemicals that were assumed to come only from SR 125. UCD determined that the February 1997 report contained numerous errors. A twenty-three page summary of UCD's findings that were specific to the report's methodology was shared with the Sweetwater Authority and its consultant so that they could revise their report accordingly.[4]

The main emphases of the written comments shared with the Sweetwater Authority are outlined below.

- Methodology: Conservative assumptions regarding the mass transfer mechanism to the reservoir and pollutant degradation rates were unrealistic. It was recommended that the report be revisited, and that, at a minimum, mass transfer at the air/water interface be accounted for properly (i.e., recognizing Henry's Law).
- Fleet Make-up: The February report assumed that mini-vans and sport utility vehicles (SUVs) would have emissions identical to those of heavy-duty trucks. Emission rates were calculated as if 30 percent of the vehicles on SR 125 would be heavy-duty trucks, an overestimation of roughly 600 percent. The report also used 1995 fleet emissions to represent 2001, neglecting several years of continued reductions in fleet average emissions as a result of the retirement of the oldest vehicles.
- Emission Rate Estimation: Emission rates were generated using a version of ARB's EMFAC model that was three releases out of date. The version of the model used did not account for any of the fuel or Smog Check program enhancements associated with the California 1994 ozone (O_3) State Implementation Plan (SIP).
- Speciation: The report failed to account for reductions in toxicity due to changes in chemical constituents of both volatile organic compound (VOC) emissions and road dust. The toxic constituents in VOC emissions were reduced with the phase-in of California RFG in 1996. The make-up of dust emissions also varies between roads. Older roadways have lead-bound soil adjacent to them; that soil can be re-entrained along with wind blown dust. Roads built after the phase out of leaded gasoline do not have residual lead contamination, and thus any re-entrained dust will be lead-free (or have dramatically lower levels).
- Dispersion Modeling: The Ogden report used the CALINE4 dispersion model, developed by Caltrans, to estimate ambient levels of pollutants over the entire Sweetwater Reservoir. This report incorrectly applied a model intended for short travel distances (e.g., less than about a few hundred meters from the emission source).

During a May 21, 1997, conference call with the Sweetwater Authority, broader comments on the selected methodology were also discussed. UCD researchers explained that

[4] This correspondence is included in a package of correspondence released by the Sweetwater Authority entitled: "Sweetwater Authority, Route 125 Correspondence, 1986 through 1999."

emissions from a single road do not have a measurable impact when compared to regional emissions, and that to do an appropriate health risk assessment, one needed to look at emissions from the entire region. UCD explained that the methodology used to prepare the February 1997 report was deficient, because it failed to place SR 125-related impacts in the context of impacts generated by the entire metropolitan region.

In an October 1997 revision to the report, Ogden accounted for some of the information Caltrans and UCD had shared, and concluded "…it is anticipated that the potential human health risks [from SR 125 air emissions] are within acceptable levels" (Ogden, 1997b, page 2-52).

5. COMMENTS ON THE BYARD STUDY

5.1 OVERVIEW AND SUMMARY

UCD reviewed the April 1999 version of the Byard report (Byard and Giroux, 1999) and determined that the report did not present credible scientific information to suggest that SR 125 air emissions pose a significant health risk to Sweetwater Reservoir users. Overly conservative assumptions already brought to the attention of the Sweetwater Authority and partially corrected in the earlier Ogden study were once again ignored. Key points illustrate this finding:

1. Major unrealistic assumptions in the Byard report overestimate health risks by a factor of at least 1,000 times (i.e., at least three orders of magnitude). This means that the Byard report's estimated year-2015-excess cancer risk of 10 cancers per 100,000 exposed people should really be no more than 0.01 cancers per 100,000 people, or, in other words, 1 excess cancer per 10 million people. That risk is well within accepted guidelines of 1 excess cancer per 1 million people. Although the report contains other flaws, the major flaws alone mean the health risks from SR 125 air emissions are within acceptable levels.
2. Numerous other flaws exist in the Byard study, virtually all of which serve to further overestimate risk.
3. A "real world" check of pollution problems at other reservoirs supports the conclusion that air emissions from nearby roads do not contribute significantly to water pollution or health risk.
4. Current regional motor vehicle emissions that are carried downwind in the ambient air and over the Sweetwater Reservoir are far in excess of the concentrations that SR 125 will generate at the reservoir.
5. The worst case assumptions embedded throughout the Byard study serve to grossly overpredict health risks associated with airborne pollutants from SR 125. Common sense, in conjunction with the existing ambient air data and modeled concentrations at the reservoir, indicates that negligible changes in water quality will occur as a result of the SR 125 project.

The remaining discussion, as well as the appendices, provides more detail about these comments.

5.2 KEY CONCERNS WITH THE BYARD REPORT

The Byard study reports a year 2015-excess lifetime cancer risk of approximately 10 excess cancers per 100,000 exposed people (worst case presented) (Byard and Giroux, 1999; Tables 11 through 13). In general, the report uses numerous unrealistic assumptions that inflate the risk estimates. Important flaws include (1) an overestimate of the air pollutants depositing onto the reservoir and (2) an overestimate of the pollutant concentration in the waters that exit the reservoir. These two problems alone indicate that the Byard report's estimated excess cancer risk of 10 cancers per 100,000 exposed people should really be closer to 0.03 cancers per 100,000 people (in other words, 3 excess cancers per 10 million people, well within the accepted guidelines of 1 excess cancer per 1 million people).[5] A brief description of these two problems follows:

1. Pollutant deposition velocities for particles overestimate by a factor of about 100 times the pollution depositing onto the reservoir. The Byard report assumes a deposition velocity of 2.0 cm/sec; a more realistic and appropriate number to use for a refined calculation is approximately 0.02 cm/sec for the assumed PAH-containing particles in the size range emitted by diesel- and gasoline-powered vehicles (Allen et al., 1996; Venkataraman et al., 1994; Venkataraman and Friedlander, 1994). Use of an irreversible deposition velocity is inappropriate for use with many of the VOCs such as benzene, MTBE, and vapor phase PAHs. The Byard report assumptions dramatically overstate the air pollution depositing onto the reservoir. Appendix C provides a more detailed discussion of this concern.

2. Pollutant steady state equilibrium assumptions made in the Byard report overestimate by a factor of about 3 times the concentration of pollutants exiting the reservoir. Independent of the pollutant deposition rates, pollutant concentration steady state conditions in the reservoir are inappropriately described. Most VOCs will approach equilibrium in the water with the ambient air level. Those compounds can deposit in or leave the reservoir depending upon whether the ambient air concentrations are greater or lower than those that would be in equilibrium with the water. For non-volatile and semi-volatile compounds, water concentrations reported in the Byard report are from 6 to 25 times too large; and for volatile compounds (e.g., benzene), the factor ranges up to greater than 150 times too high. Particulate matter (PM) steady state conditions overestimate the amount of average pollutant mass per unit time that could possibly exit the reservoir by a factor of 3. VOC steady state conditions fail to consider Henry's Law coefficients and other factors that significantly reduce the pollutant concentration. Note that UCD expressed similar concerns two years ago when UCD reviewed the draft Ogden report (1997a). Appendix D provides a more detailed discussion of this concern.

5.3 EXAMPLES OF OTHER BYARD STUDY FLAWS

In addition to the two major problems discussed above, the report contains numerous other flaws that serve to exaggerate the potential risk by an additional factor of about 10 times. Some notable examples:

5.3.1 Vehicle Activity

- The report assumes unrealistically high growth rates in vehicle traffic. Despite recent vehicle activity growth rates of approximately 3.5 percent per year (Byard and Giroux, p. 5), the report assumes a 10 percent rate of growth in annual vehicle traffic for northbound crossings at Otay Mesa. This may overpredict vehicle activity by a factor of 2 to 3.

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[5] It should be noted that the estimated cancer risk numbers do not mean that people will actually develop that number of cancers because the potency factors are generally believed to provide a conservative estimate. However, relative changes in the numbers provide a sense of whether a given change reduces or increases the risk.

- The report assumes the highest identified percent of Mexican vehicles crossing the border from Mexico into the United States. This figure, 50 percent, is used even though the report documents that it is the oldest data reported (1993) and that more recent data support a smaller estimate. For example, the report documents a 1996 survey that shows 37 percent Mexican vehicular activity and a 1997 report that shows 29 percent (Byard and Giroux, p. 4). This assumption may overpredict Mexican vehicular activity by about a factor of 2.

- The report assumes high numbers of Mexican vehicles using SR 125. It forecasts that Mexican trucks will comprise 2 to 3 percent of the total vehicular traffic on SR 125, based on 64,000 vehicles per day in the year 2000 and 2000,000 vehicles per day in 2015 (Byard and Giroux, 1999, Table 1). However, SANDAG estimates reduced Mexican vehicular traffic, especially truck traffic, on SR 125 due to (1) planned tolls for using SR 125 and (2) an assumption that many Mexican trucks simply transfer their loads to United States vehicles and return to Mexico. In addition, the analysis contained in SR 125's draft EIR/EIS forecasted that Mexican trucks would represent less than one percent of SR 125's total vehicular volume (Stoll, 1999).

5.3.2 Emissions Information

- The report identifies motor vehicle emissions information from various sources, many of which are outdated. As one example, information concerning benzene emissions from gasoline use is drawn from a study that predates the implementation of California's RFG program which significantly reduced gasoline's benzene content. [See Appendix A for a more complete discussion of this topic.]

- The report includes unusually high emission rates for Mexican vehicles compared to U.S. vehicles. The Byard report uses ARB estimates for Mexican vehicle emissions, and then multiplies those emissions by an additional factor of 4.5. Dr. Byard informed UCD verbally that the justification for these data were from the El Paso, Texas/Juarez, Mexico border area. However, a recent remote sensing study conducted by the Desert Research Institute (Walsh and Gertler, 1997) found that, on average, Mexican vehicles in the El Paso/Juarez area emit approximately 2 to 2.5 times more CO and HC than Texas vehicles.

- The information that the Byard report used to characterize diesel emissions did not reflect recent California fuel regulations. Researchers have found that unburned fuel is a major source of the lower molecular weight PAH found in diesel exhaust particles (Miguel et al., 1998). Therefore, changes in fuel composition could impact emissions of these compounds. In 1993, new regulations were instituted in California mandating that the aromatic content of diesel fuel could not exceed 10 percent, which is about one-third of the level of pre-1993 diesel fuel. In addition, the 1993 reformulation of California diesel fuel has resulted in a 25 percent reduction in PM emissions, and reductions in air toxics emissions, including emissions of benzene and of PAH (California Air Resources Board, 1997).

5.4 ADDITIONAL COMMENTS

There are a number of other concerns about the report that are not detailed here. Examples include the following:

1. It is assumed that 100 percent of the PAH particles pass through the water treatment plant and are available for ingestion. Sweetwater Reservoir's existing water treatment facilities will likely filter out larger particles (particles that could actually have deposition velocities corresponding to the 2.0 cm/s assumed) before they reach water consumers (the water is filtered through sand and anthracite coal). The Byard report does not assume any pollutant removal due to water treatment. It has been estimated that only about 20 percent of the particles pass through treatment facilities (Ishimaru et al., 1990).
2. Of the 17 major compounds cited as causing a health risk due to carcinogenicity, only 7 of those compounds are listed in any database as actually or potentially carcinogenic. The Byard report's listing of the compounds as carcinogenic is based on evidence of mutagenicity. However, neither the EPA, nor the U.S. Department of Health and Human Services considers this evidence sufficient to list the compound as actually or potentially carcinogenic. Based on this point alone, the correct risk should be only about 38 percent of the risk estimated by the Byard report. Consequently, the Byard report overestimates the cancer risk by approximately a factor of 3.
3. The assumption of the exposure analysis is that the exposure due to inhalation and dermal contact is 50 percent of the exposure due to ingestion. PAHs do not usually enter the skin under normal conditions. Dermal exposure could only result from contact with products or oils containing high concentrations of PAHs (U. S. Department of Health and Human Services, 1998). This type of exposure does not pertain to the present analysis, and dermal exposure is expected to be negligible. The loss of the dermal exposure pathway reduces the overall exposure by 15 to 20 percent.
4. Conservation of mass is ignored in the transport of pollutants from the roadway to the reservoir. If deposition velocities as large as 2 cm/s were realistic and were used, appreciable mass would deposit before highway-related air emissions reached the reservoir. However, if realistic deposition velocities are used, insignificant mass will deposit and that is not a problem.

Virtually all of the above concerns relate to assumptions that serve to exaggerate potential health risks.

5.5 SUMMARY ANALYSIS OF BYARD REPORT

The report's analysis methodology includes numerous assumptions that unrealistically bias the risk estimates. Report assumptions:

- Pick the worst case vehicle activity data (e.g., older data, rather than more recent data); then

- Use the worst case assumptions for emissions from each of those vehicles (e.g., use outdated data; use diesel vehicle information to characterize gasoline vehicle emissions); then
- Assume the worst case for pollutant deposition (fail to consider atmospheric interactions and lifetimes of chemicals and use inappropriate deposition rates); then
- Incorrectly calculate the pollutant concentrations in the reservoir (fail to consider Henry's Law and other factors that affect steady state concentrations); and then
- Assume worst case for exposure (e.g., assume none of the pollutants are removed by water treatment, and that greater amounts of pollutant leave the reservoir than enter it).

The resulting health risk estimates are overstated. Actual risks easily fall within acceptable limits of 1 excess cancer per 1 million people by adjusting two of the most problematic assumptions (those relating to pollutant deposition velocities, and pollutant steady state equilibrium assumptions). More importantly, the ambient air data illustrate that imperceptibly small increases in deposition will occur in the reservoir compared to current deposition rates given the existing air quality near the reservoir.

6. OTHER OBSERVATIONS

As part of the SR 125 and Sweetwater Reservoir review, UCD identified information related to other reservoirs, existing air quality regulations, and the status of motor vehicle control programs related to air toxics. Highlights of the findings are included here.

6.1 "REAL WORLD" CHECK AGAINST MONITORED POLLUTANTS AT OTHER RESERVOIRS

A "real world" check on water quality at other reservoirs helped confirm that SR 125 air emissions are not likely to generate any significant health risks for Sweetwater Reservoir users. UCD identified other California reservoirs in close proximity to roads, and did a brief analysis to identify whether vehicle-related air pollutants posed a problem for water quality. The review, which included discussions with reservoir staff, identification of meteorological data to determine prevailing winds near reservoirs, and report reviews, found no scientific evidence to suggest nearby roadway air pollutant emissions contribute significantly to water pollution.

An example of the findings from this review includes MTBE data from Castaic Lake. Castaic Lake has a water residence time approximately equal to that of the Sweetwater Reservoir (i.e., one year) and is located downwind of Interstate-5. MTBE tends to be more persistent in the water supply than other chemicals and thus serves as a conservative signature for motor vehicle-related pollution. If MTBE is not found at problem concentrations, that is a good indicator that other vehicle-related compounds are also not likely to be present at harmful concentrations. In reviewing MTBE data, it is important to separate MTBE that may be discharged directly into the water from recreational boating from MTBE that has been emitted into the air from motor vehicles. At Castaic Lake, where recreational boating is allowed, one way to reduce the influence of recreational boating is to observe winter-time MTBE levels, when recreational boating is reduced. Winter-time MTBE levels (1997) at Castaic Lake were below California water quality standards. Even if all the MTBE observed during the winter were from atmospheric deposition, rather than any recreational boating (an unlikely assumption), the low pollutant levels observed help illustrate why roadway-related VOC atmospheric deposition is not a likely significant contributor to pollution in a nearby reservoir. Appendix E includes more information from this UCD review.

6.2 EXISTING AIR QUALITY REGULATIONS

SR 125 complies with state and federal air quality regulations. The U.S. Environmental Protection Agency (EPA), together with the Federal Highway Administration (FHWA), has established regulations specifically designed to evaluate transportation projects and to insure that such projects conform to a region's air quality control efforts. These regulations, referred to as the "conformity" requirements, are designed to scale air quality analyses to scientifically appropriate levels. Simply put, regional pollution problems, such as O_3 and PM, are handled by evaluating pollution from all sources throughout a metropolitan area, including the region's transportation system as a whole, rather than by evaluating individual projects. Regional analyses also have to consider pollutants transported into a region from upwind areas. For example, a portion of the San Diego area's air pollution problems is attributed to polluted air being transported from the Los Angeles region; regional analyses consider the contribution from such pollutant transport. In contrast to PM and O_3, CO problems are addressed on a project-specific basis. The control of CO from motor vehicles is one of the air quality community's major success stories, and CO is no longer considered problematic in the San Diego region. The SR 125 project conforms to all CO, PM, and O_3 requirements.

6.3 OTHER COMMENTS ON AIR TOXICS CONTROL ISSUES

As stated earlier in this report, UCD finds no evidence to suggest that SR 125 air toxics emissions will be a concern. UCD reached this conclusion, in part, by reviewing the underlying assumptions in the Byard and Ogden reports. Independent of the problems associated with the Byard and Ogden reports, however, air toxics emissions from vehicles using SR 125 are likely to be reduced over time. The federal and state governments have ongoing active diesel and gasoline fuel reformulation programs to reduce benzene and other air toxics from motor vehicle emissions. For example, California Governor Gray Davis recently announced that the fuel additive MTBE must be phased out of California's gasoline supply no later than December 31, 2002. At the federal level, the EPA is under a court-ordered deadline to propose national mobile source air toxics requirements by late 1999. The EPA has published a draft "Integrated Urban Air Toxics Strategy," which describes the EPA's plan to issue a notice of proposed rulemaking for mobile source standards in 1999 and a final rulemaking in the year 2000 (U.S. Environmental Protection Agency, 1998).[6]

[6] Note that the EPA is expected to finalize and publish a final version of its "Integrated Urban Air Toxics Strategy" by early July 1999 (after completion of this report). In addition, the EPA is negotiating to extend the court-ordered deadline for publication of its mobile source air toxics rulemaking. The final strategy document, and subsequent court negotations, may revise the EPA's mobile source air toxics rulemaking schedule.

7. CONCLUSIONS

Sweetwater Authority-sponsored reports (Ogden, 1997a and 1997b; Byard and Giroux, 1999) significantly overstate the health risks associated with air emissions from SR 125. The reports overpredict emission rates, use dispersion and mass transfer models that result in an over-prediction of pollutant levels in the reservoir, and neglect to account for processes that remove the pollutants from the water prior to consumption. Correcting these errors and using more realistic, refined assumptions produce estimated risks that fall below the significance thresholds established by the regulatory community. In fact, the Sweetwater Authority-sponsored Ogden report (1997b) also concludes that "…the potential human health risks [from SR 125 air emissions] are within acceptable levels."

Overall, the risk assessment methodologies used by the Sweetwater Authority-sponsored reports are inappropriate. By focusing on emissions from SR 125 alone, the reports have neglected to account for existing regional emissions that are at least 250 to 500 times more important than potential future emissions from SR 125. If air pollution contributes to the degradation of surface waters, then regional impacts, rather than project impacts, would be the appropriate scale at which to conduct studies and take mitigatory action, if needed. Indeed, if the Byard report assumptions were correct, then the existing ambient air conditions at the reservoir would indicate about 200 excess cancers in Sweetwater Reservoir's customers today from benzene alone, in contrast to the Byard report's estimate that 0.8 excess cancers will be associated with SR 125 benzene emissions. The Sweetwater Authority reports no detection of chemicals such as benzene in their water quality monitoring program, and common sense indicates that the projected impacts of SR 125 would therefore be immeasurably small.

8. RECOMMENDED FURTHER RESEARCH

If further research is considered, UCD recommends that a broader review of air pollution and drinking water be undertaken to determine what, if any, long-term research efforts might be useful. Such research may be appropriately undertaken by a variety of public health and/or environmental management agencies, and UCD does not recommend which agencies are most appropriate for conducting such work. These research efforts, if pursued, would need to comprehensively measure and evaluate numerous factors, including the following:

- regional air pollutant transport;
- ambient background pollutant concentration levels in all areas adjacent to the water body;
- the methods by which pollutants deposit onto, evaporate out of, settle from, and are mixed into the water body;
- the relative pollutant contributions made by various pollution sources; and
- the effectiveness of routine and existing water treatment processes in removing potentially harmful compounds originating in the air.

Conceptually, we recommend dividing future research efforts into six phases. The phases are roughly sequential so that findings of concern during one phase should motivate continued research efforts and movement to subsequent research phases. The six phases include:

Phase 1: Use the Byard report's analytical approach to predict the concentration of pollutants expected in the water supply, based upon existing regional air toxics concentrations. The goal would be to compare pollutant concentrations predicted by the Byard methodology to "real world" values.

Phase 2: Evaluate existing drinking water data from various reservoirs located near major roadways. The goal would be to determine whether air pollution is contributing significant additional health risks to drinking water supplies.

Phase 3: Establish a study protocol to evaluate whether regional air pollution problems degrade water quality in California drinking water reservoirs. The study design could include specific tasks to evaluate project-level impacts, but we recommend that, given the much greater importance of regional pollution, the protocol should first focus on regional pollution problems. The goal would be to reach consensus among air and water quality experts as to the best, scientifically sound approach for evaluating the relationship between regional air pollution and water quality.

Phase 4: Implement short-term (i.e., one- to three-year) monitoring at several study locations to measure air pollution concentrations and pre- and post-treatment water pollution concentrations. The goal would be to implement the first part of the study protocol (developed under Phase 3), and to determine whether there is any evidence to support the need for long-term monitoring, data analysis, and risk assessment work.

Phase 5: Evaluate monitoring results. The goal would be to document the relationship between air pollution and water quality. If the research findings suggest a cause for concern, longer-term monitoring programs can be initiated.

Phase 6: Implement long-term air and water quality monitoring but only if prior research suggested a need to do such monitoring, and only if available measurement methodologies are sufficiently sensitive.

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APPENDIX A

BENZENE EXAMPLE OF REGIONAL VS. PROJECT-LEVEL POLLUTION

Highlights

- Regional benzene emissions will be about 500 times more important than SR 125-specific benzene emissions in determining benzene concentrations in the Sweetwater Reservoir.
- The Byard report uses outdated emissions information which doubles the benzene emissions expected from vehicles using SR 125.
- The Byard report uses a number of unrealistic assumptions that drastically overstate anticipated health risks from benzene in the water supply.
- Ignoring the problems of overstated benzene concentrations in the water supply, the implications of the Byard report are that by the year 2015, more than 400 Sweetwater Reservoir users would experience excess cancer risk due to benzene exposure, less than 1 case of which would be associated with SR 125 emissions. If significant risks actually were to occur from SR 125, **they must already exist at a much greater level in the reservoir now** from benzene alone. There is no evidence to indicate that this has happened.

Background

The Byard report predicts significant cancer risks associated with air emissions from vehicles using SR 125. A closer examination of those risks helps to illustrate how the report (1) overestimates health concerns from SR 125 and (2) fails to appropriately evaluate this issue as a regional problem. This discussion uses the pollutant benzene as an example. Benzene exists in gasoline and, therefore, in motor vehicle emissions. The Byard report estimates that SR 125's build-out will contribute enough benzene emissions to trigger about 10 excess cancers per million people exposed through the Sweetwater Reservoir's water supply.

- Byard estimates benzene air concentrations to be 1.9 parts per trillion (ppt) over the reservoir, due to SR 125-related traffic.
- Background benzene concentrations monitored by ARB (in 1997) in the San Diego area were 600 ppt at El Cajon, and 428 ppt at Chula Vista (an average of 514 ppt, or about 250 times more than the 1.9 ppt associated with SR 125).

- Thus, the urban background concentration is approximately 250 times greater than the concentration predicted by the Byard report with respect to SR 125. In other words, benzene concentrations observed in the reservoir would be overwhelmingly dominated by regional emissions (250 times more important) than from SR 125.
- Even these numbers overestimate the impacts of SR 125, however, for two reasons: (a) the Byard study makes unrealistic assumptions that artificially inflate the concentration of benzene in the water, and (b) benzene emissions from SR 125 traffic will further be reduced to about one-half the levels predicted by the Byard study, when RFG use is considered. [As background information, RFG has been in use in the San Diego area since 1995 and has lowered ambient benzene concentrations by approximately 30 to 60 percent; the Byard study used data that pre-dates the implementation of RFG.]
- Thus, without further adjusting for other unrealistic assumptions included in the Byard study, it is reasonable to say that regional benzene emissions will be about 500 times more important than SR 125-related emissions when considering the concentration of benzene in the Sweetwater Reservoir.
- Further risk reductions are appropriate, however, because the Byard report substantially overpredicts the pollutant concentrations occurring in the reservoir.

Some Further Details on the Computed Air, Water and Risk Calculations for Benzene

- Byard estimates that in 2015, assuming Alternate 2 (the Caltrans preference) is built, approximately 16.5 lifetime cancers would be expected among the 177,000 Sweetwater Reservoir users. This estimation translates to 93 cancers per million people exposed during their lifetime.
- Fifty percent of the Byard report's risks come from just four pollutants, one of which is benzene.
- Byard estimates that benzene contributes 11 percent of the total health risk.
- The Byard report, therefore, estimates that exposure to benzene from nearby traffic on SR 125 and SR 54 will lead to an approximate excess cancer risk of 10 cancers per million people (11 percent of 93).
- The report's health risk assumptions are based on benzene from SR 125 and from SR 54 resulting in an average air quality concentration over the reservoir of 1.9 parts per trillion (ppt) of benzene.
- The ARB currently monitors for ambient benzene levels in El Cajon and Chula Vista. These stations are "neighborhood scale" stations sited to be representative of background air quality over a spatial area of one-half to a few kilometers. The ARB reports that the average ambient benzene concentration in 1997 was 600 ppt at their El Cajon site and 427 ppt at their Chula Vista monitoring site—suggesting that 1997 background benzene levels at the Sweetwater Reservoir are about 250 times greater than the conservatively high estimated 2015 impact from the project.

- Using the Byard report's methodologies, projected calculations would show that ambient, pre-project benzene levels would result in 2,500 cancers per million (250 times the 10 cancers per million people associated with SR 125 emissions), or roughly 443 of Sweetwater Reservoir's current customers (443 is 17.7 percent of 2,500; 177,000 reservoir users is 17.7 percent of a million people). Nevertheless, there are no data to suggest that current benzene levels exceed drinking water quality standards. Common sense indicates that the assumptions used in the Byard report are faulty.
- In addition, Byard's data pre-dates the implementation of the federal and California RFG programs. Those programs, begun in 1995, have been demonstrated to reduce benzene concentrations by 30 to 60 percent.
- Considering implementation of RFG programs, the air concentrations of benzene over Sweetwater Reservoir from SR 125 and SR 54 are approximately 500 times less than the ambient background concentrations monitored at El Cajon and Chula Vista.

If benzene from air pollution is truly a public health concern for Sweetwater Reservoir users, then only about $1/500^{th}$ of the problem will be associated with the operation of SR 125, and the rest of the problem will be associated with general background conditions.

Bear in mind that this look at benzene does not address the other unrealistic assumptions made by the Byard report in projecting how ambient air concentrations translate into water pollution and public health risks.

Brief Documentation Illustrating How Benzene Has Been Reduced by RFG

Several studies show that significant decreases in ambient benzene concentrations (30 to 60 percent) have occurred following the implementation of RFG in California (and in other parts of the US). To help meet clean air standards, the Clean Air Act Amendments of 1990 (CAAA) required the use of RFG in the nine worst O_3 nonattainment areas of the country. San Diego is one of the areas required to implement this program. A key difference between Federal Phase I RFG and conventional gasoline is that RFG has significant reductions in benzene and total aromatic hydrocarbon levels in the fuel and consequently in the exhaust and evaporative emissions. The federal RFG requirement has two key phase-in milestones: Phase I RFG was required to be available at gasoline retail operations beginning January 1, 1995. Phase II RFG, which will require further hydrocarbon and toxic reductions, is required to be available in the year 2000. In addition, California has had separate fuel requirements that also require gasoline reformulation that target benzene reductions (implemented in early 1996). Following are data references that document a 30 to 60 percent reduction in ambient benzene: ARB (Hammond, 1996), University of California, Berkeley (Kirchstetter et al., 1999), Sonoma Technology, Inc. (Main et al., 1998, 1999a, 1999b), and Desert Research Institute (O'Connor et al., 1998; Zielinska et al., 1997).

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APPENDIX B

EMISSIONS DENSITY PLOTS FOR THE SAN DIEGO REGION

Discussion

Attached are two figures that show CO emissions in the San Diego metropolitan area. **Figure B-1** covers much of southern California, including Los Angeles and San Diego. **Figure B-2** is an enlargement of the San Diego metropolitan area, with the Sweetwater Reservoir indicated. Also, Figure B-2 displays prevailing wind direction and wind speeds. The figures illustrate the latest available spatially plotted data for CO emissions in the San Diego region.

Since the vast majority (typically 70 to 90 percent) of all CO emissions are from mobile sources, these plots are a surrogate for portraying air pollution from motor vehicles in the San Diego area. Although the exact quantity and location of CO emissions will differ now compared to the 1990 data presented, the data are still valid indicators of the broad patterns of where motor vehicle emissions occur in the San Diego region. The plots demonstrate several points:

1. Most of the motor vehicle emissions occur in the highly developed western regions of the San Diego metropolitan area.
2. Prevailing winds generally carry motor vehicle emissions to the east and southeast.
3. The vast majority of the region's motor vehicle emissions are directly upwind of the Sweetwater Reservoir.

These figures help to illustrate that roadway-related air emissions from SR 125 will be only a small fraction of the overall mobile source emissions carried over the reservoir.

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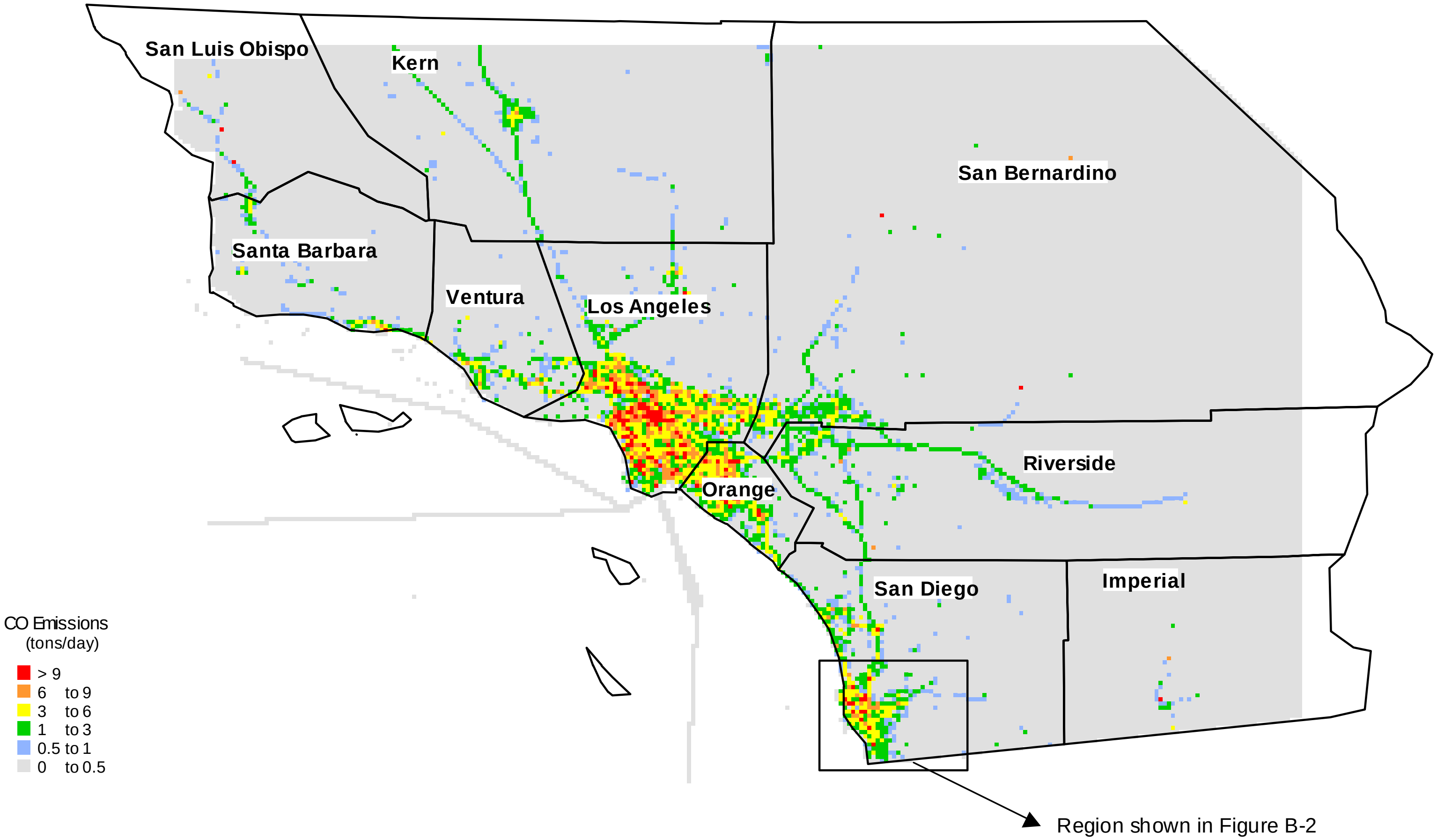
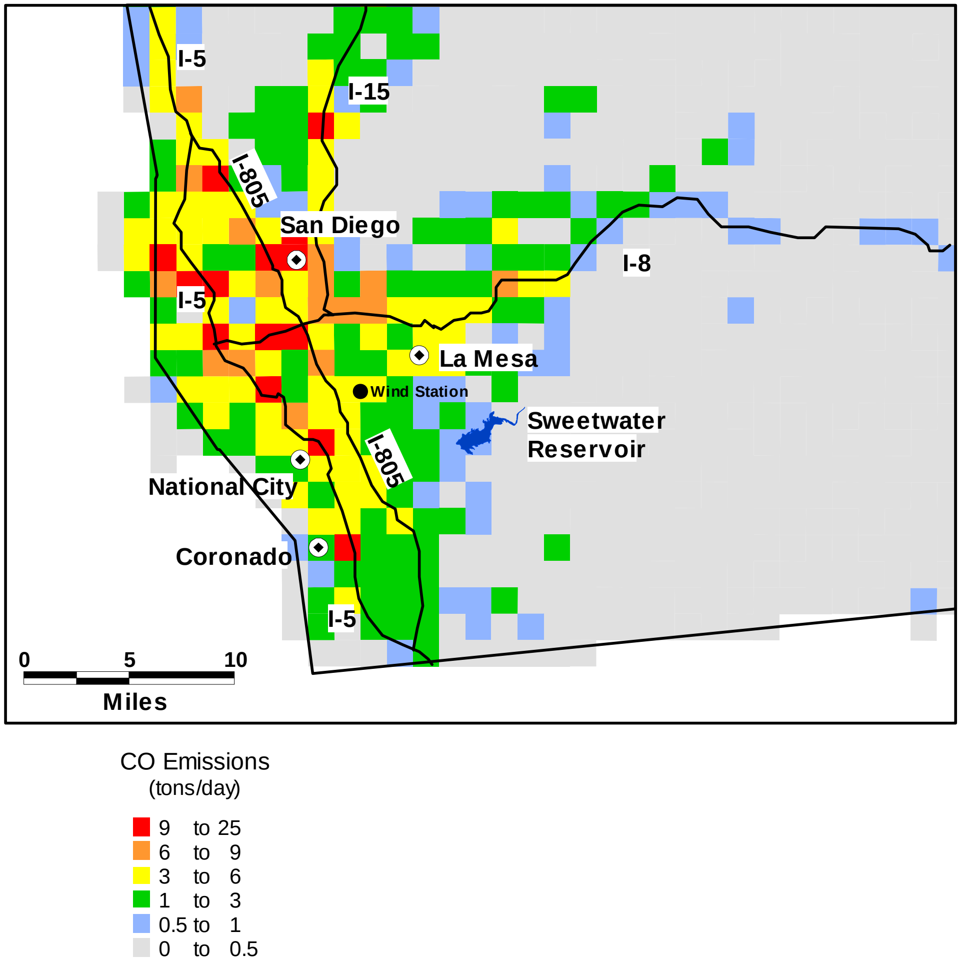


Source of Emissions Data: 1990 South Coast Ozone Study (SCOS) emission inventory obtained from ARB; emissions for point, area, mobile, and biogenic sources. This is the most recently available gridded emission inventory for the South Coast region.

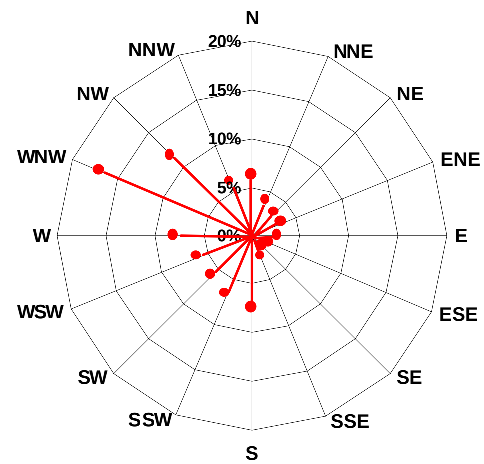
Figure B-1. Carbon monoxide emissions density plot for southern California.

CO Emissions in the Southwestern Portion of San Diego County

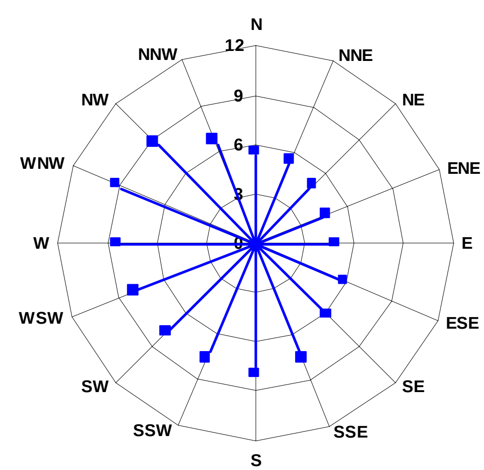


Source of Emissions Data: 1990 South Coast Ozone Study (SCOS) emission inventory obtained from ARB; emissions for point, area, mobile, and biogenic sources. This is the most recently available gridded emission inventory for the South Coast region.

Average Annual Wind Direction



Average Annual Wind Speed
(miles/hour)



Wind plots based on 15 years worth of surface meteorological data collected in San Diego (ARB Aerometric Data Division; *California Surface Wind Climatology*, 1984).

Figure B-2. Carbon monoxide emissions density plot and meteorological information for the San Diego metropolitan area.

APPENDIX C

CONCERNS WITH BYARD REPORT DEPOSITION VELOCITY ASSUMPTIONS

Overview

The "deposition velocity" is a modeling construct used to provide an estimate of the flux of material (gases or particles) depositing on a surface, given that an average concentration at some reference height above that surface and other environmental parameters are known. The deposition velocity does not represent the "true" physics or chemistry of the deposition process, nor does it account for partitioning of vapors between the gas phase and particle surfaces. In its more general forms, the deposition velocity incorporates both gravitational settling and turbulent and molecular diffusion processes. The current modeling guidelines used by the ARB permit use of the deposition velocity algorithm used in the USEPA ISC3 models. The majority of Gaussian plume models used for screening and refined analysis (e.g., SCREEN) do not incorporate plume depletion and hence do not conserve total mass. However, the latest version of ISC3 does; but, as noted elsewhere, it requires size distribution data. If size distribution data are available, they can be used to compute the deposition flux with a model such as ISCST3 with air district approval.

Problems with Byard Report Approach

From our discussion with Dr. Byard, the ISC3 algorithm was apparently not used for the PAH particle size distribution. Thus, just as the Byard report's analysis did not conserve mass when estimating pollutant outflow from the reservoir, the report also did not conserve mass when estimating the pollutant plume moving from an emission source towards the reservoir (i.e., the report did not properly estimate "plume depletion"). When the source is located at ground level, is distant (scenario #3), and a large deposition velocity is used (e.g., 2 cm/s, as the Byard report assumed) mass in the plume is not conserved and deposition is badly overestimated.

Note that the deposition velocity assumption (independent of assuming no plume depletion) is multiplicative with the overestimate of the mass flux out of the reservoir. Hence the overall error associated with those two calculations was at least a factor of 100 to 300 times too large.

Whereas ISC3 is often thought of as an air model that is more "refined", the application of ISC3 in this case was not "refined." There are measured size distributions of atmospheric aerosols and diesel particle size distributions, and, at worst, they should have been used (Allen et al., 1996; Venkataraman et al., 1994; Venkataraman and Friedlander, 1994). Furthermore, the analysts did not provide any enhanced vertical dispersion, which many studies have shown occurs over roadways. A volume source should have been used in that case, but that error is probably not as large an overestimate because of the distance from the road to the reservoir, particularly the segment of the SR 54 extension that contributes over half of the calculated risk in the Byard report.

The deposition velocity used in the Byard report (2 cm/s) is acceptable for PM_{10}. However, measurements indicate that the majority of the PAH mass in "fresh" vehicle emissions is associated with particles in the ultrafine and fine modes (0.05 - 0.12 um diameter) (Venkataraman et al., 1994; Miguel et al., 1998). In more "aged" urban particles, the PAH distribution contains a second peak in the 0.5-1 um size range (Venkataraman et al., 1994; Allen et al., 1996). The fraction of PAH associated with smaller particles increases as molecular weight increases (Allen et al., 1996). The semi-volatile (4-ring) PAH are primarily on particles in the accumulation mode (0.5-1.0 um) after aging. The nonvolatile PAH (5-ring and larger) are found mainly on particles in the ultrafine mode (0.05-0.12 um range) (Venkataraman and Friedlander, 1994). Because of the proximity of the emission source to the reservoir the travel time is short, and there is little time for the redistribution of mass from the ultrafine particles to the fine particle mode.

For the particle sizes with which PAHs are associated in ambient conditions, 2 cm/s is too large a deposition velocity. Slinn and Slinn (1980) modeled the deposition velocities of particles over water surfaces. For the particles that contain the majority of PAH mass in fresh vehicle emissions (those in the 0.05 – 0.12 um size range), the deposition velocity would be approximately 0.02 cm/s. For the PAH in aged aerosols (particles 0.5 to 1.0 um in diameter), the predicted deposition velocity would also be about 0.02 cm/s. Thus, the PAH deposition was overestimated by a factor of 100.

The PAHs and VOCs that are in the gas phase will not deposit according to an irreversible dry deposition law. They will partition according to Henry's Law and, during periods when cleaner air moves over the surface of the water, they will be volatilized from the water body. Thus, the assumption of accumulation of two months of VOC has no scientific basis or merit.

Neglecting gas-water equilibrium can lead to an overestimation of the water concentrations of VOCs. Benzene can be used to demonstrate this point. The Byard report predicts an average benzene air concentration over the reservoir of 1.9 ppt for Alternative 2 in Year 2015. Applying Henry's Law to this air concentration would result in an equilibrium water concentration of 0.027 ug/L. Byard predicts a concentration of 6.22 ug/L, which is over 200 times larger than the equilibrium concentration calculated with Henry's Law and above drinking water standards. Given existing ambient air concentrations of benzene, there should already be routine violations of the drinking water standard for benzene if the assumptions in the Byard report are correct. The fact that such violations are not currently detected help illustrate that the Byard report overpredicts pollutant concentrations, exposure, and risk.

Appendix C References

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APPENDIX D

CONCERNS WITH BYARD REPORT STEADY STATE EQUILIBRIUM ASSUMPTIONS

Introduction

This appendix discusses two problems associated with Byard report equilibrium pollutant concentration calculations: (1) problems with PM, and (2) problems with VOCs.

Problem Discussion 1: Conservation Of Mass Problems With Particulate Based Pollutant Analysis

The estimates of the concentrations of various contaminants within the reservoir are central to the overall assessment. The Byard report assumed that inputs to the reservoir would be by two paths: 1) the chemicals sorbed to and carried by particles that are deposited in the reservoir and 2) volatile chemicals that dissolve into the water from the air above the reservoir.

The Byard report reasoned that chemicals sorbed to PM emitted along the freeway would be carried into the reservoir with the PM deposited onto the maximum reservoir surface. Byard assumed that although the reservoir level and surface area would fluctuate over time, at some point within any year the reservoir would be full. All PM that had been deposited on the reservoir bottom when it was exposed now would be suspended in the water. The Byard report assumed that there would be no reaction, volatilization, resuspension into the atmosphere, or other losses from the PM deposited on the exposed soil. The Byard report further assumed that there is no sedimentation, decomposition, or other losses within the reservoir. These are an unrealistically conservative set of assumptions.

Accepting all these assumptions, however, the maximum possible concentration for PM will occur at steady state. This approach must satisfy a simple materials balance over long periods of time, such as a lifetime of exposure or even shorter durations. If there is no other source of a chemical, more cannot be exiting the reservoir than is deposited into it.

The mass rate of PM deposition over the reservoir was projected in the Byard report using an air model for each of the various freeway alignment alternatives, assuming a mass emissions rate of 1.9823 tons of PM emitted per mile of freeway each year. The deposition rate was then scaled for actual projected emissions rates of 2.42 tons per mile per year in 2000 and 3.51 tons per mile per year in 2015. Assuming that the overestimated emission rates were correct, which they are not, and using the average outflow from the reservoir, the average mass of PM leaving the reservoir per unit time can be calculated using the Byard report water concentrations. This can be compared with the mass of particles deposited into the reservoir per unit time provided in the Byard report by adding the deposition rate from SR 54 to the different deposition rates from SR 125 alignment scenarios 1, 2, and 3.

Conservative estimates of contaminant concentration can be obtained by assuming that the only outflow from the reservoir is water use. In conversations with Dr. Byard and the Sweetwater Authority, we have been told that the flow rate of water out of the reservoir is about 23,000 acre-ft per year.

The deposition rate for Scenario 2 in the year 2015 is used as an example and is summarized in **Table D-1**. For the SR 54 extension, Byard calculated a deposition rate for PM of 403 kg/yr. For SR 125 Alternative 2, the deposition rate used was 324 kg/yr. The total deposition rate for Scenario 2 (sum of SR 54 and SR 125 Alternative 2 contributions) was 727 kg/yr. This represents the yearly input of PM into the Sweetwater Reservoir from the project. Byard predicts a PM water concentration in the year 2015 of 84.3 ug/L for Scenario 2. Multiplying this concentration by the yearly water flow rate (23,000 acre-ft/yr) yields an outflow rate for PM of 2394 kg/yr. This represents the yearly output of PM from the reservoir. Thus, the assumed particulate mass exiting the reservoir is 3.3 times (2394 kg/yr / 727 kg/yr) the mass entering the reservoir.

Table D-1. Summary of PM mass balance for Scenario 2 in year 2015.

Column 1	Column 2	Column 3	Column 4	Column 5
Routing (Scenario 2)	Dep rate (ton/yr)	Dep rate (kg/yr)	PM water concentration from Byard report (ug/L)	PM exiting reservoir at outflow of 23,000 acre-ft/yr (kg/yr)
SR54	0.444	403	46.7	1326
Alt 2	0.358	324	37.6	1068
Total Values for Scenario 2	0.802	727	84.3	2394
Mass in/mass out ratio:	3.3 (Equal to Column 5 divided by Column 3)			

It is seen that in the year 2015 the amount of PM mass exiting the reservoir is a factor of 3.3 greater than deposited into the reservoir, an impossibility. The same methodology was used in the year 2000, yielding a factor of 2.4 overestimate. Concentrations of specific polycyclic aromatic hydrocarbons (PAHs) deposited with particles were estimated by multiplying the concentration of the specific PAH in PM by the concentration of PM in the reservoir. Thus, the particulate associated pollutant concentrations are overestimated by a minimum of a factor of 2.4 in the year 2000 and 3.3 in the year 2015. In addition, Dr. Byard assumed that some of the PAHs partition to the gas phase, but those pollutants should then have been treated using the Henry's Law approach. For a compound such as phenanthrene, which is semi-volatile, the overestimated water concentrations are about a factor of 25 too large.

Problem Discussion 2: Overestimation of VOC Deposition Due To Air – Water Equilibrium / Exchange Problems (i.e., Henry's Law)

Volatile contaminants may enter the reservoir by dissolving from the air above the reservoir surface. The maximum concentration for this route, assuming that there is no release of a volatile compound from the deposited PM and without any transformations in the reservoir, will occur when the reservoir is at equilibrium with the air. The partial pressure of a VOC in the air and the equilibrium concentration in the water are related by the Henry's Law coefficient for that VOC. The Byard report did not use Henry's Law to calculate the VOC water concentrations. Instead, the report used the same irreversible deposition model that was used for PM. This is inappropriate, since VOCs do not exhibit the same deposition behavior as particles.

The equilibrium water concentrations of benzene in the various scenarios are presented in **Table D-2**. Benzene is a volatile compound that occurs almost exclusively in the exhaust vapor phase. The water concentrations predicted by the Byard report are also shown. A comparison between the values shows that the Byard report overpredicts the benzene concentrations in the year 2000 by more than a factor of 150 and by more than a factor of 200 in the year 2015.

Table D-2. Estimated concentrations of benzene in the Sweetwater Reservoir resulting from SR 54 and alternative alignments for SR 125.

	Calculated Concentration of Benzene in Reservoir Accounting for Henry's Law		Byard Report's Estimate of Benzene Concentration in Reservoir, Neglecting Henry's Law	
	2000 (µg/L)	2015 (µg/L)	2000 (µg/L)	2015 (µg/L)
Alternative 1	0.0290	0.0309	4.79	6.83
Alternative 2	0.0255	0.0272	4.21	6.22
Alternative 3	0.0215	0.0229	3.55	5.50

Henry's Law coefficient used for calculations: 0.18 mol/L•atm at standard temperature and pressure.

APPENDIX E

BRIEF REVIEW OF INFORMATION ON RESERVOIRS NEAR HIGHWAYS

Introduction

UCD researchers identified several examples of California reservoirs located near highways. UCD then contacted reservoir management staff to gather background information and to identify available water quality data. **Table E-1** summarizes some of the information collected.

Table E-1. Summary information for reservoirs near major roadways.

Source Water	Residence Time of Drinking Water in the Reservoir	Max Capacity (acre-ft)	Distance to Roadway (in meters)	Monitoring Results
Castaic Lake	1+ year	350,000	~100-200m from I-5 (southern end of lake)	MTBE – average values below 10 ug/L in 1997
Silverwood Lake	~1 month	78,000	~150m from Hwy 138 at closest point	MTBE – average values below 5 ug/L in 1997
Los Angeles Reservoir	~ 8 days	10170	~ 180m from I-5 at closest point	MTBE – 11 samples over two years, all ND
Crystal Springs		~57900	~ 200m from Hwy 280	MTBE – monitored for a couple of years, all ND; very low number of detects for anything other than disinfection by-products
San Andreas		~ 19000	~ 200m from Hwy 280	MTBE – monitored for a couple of years, all ND; very low number of detects for anything other than disinfection by-products
Sweetwater Reservoir	~ 1 year	~ 28,000, but operates below capacity most of the time	~200 to 600m from SR 125, depending on configuration chosen.	According to their Annual WQ reports, ND for all organics tested in the treated water, with the exception of THMs. THM values averaged 0.073 mg/L (0.1 is standard) in 1998*

* Trihalomethanes (THMs) are not emitted from vehicles in measurable quantities and are largely formed by chlorination of natural waters for disinfection purposes.

Table Sources: Metropolitan Water District (1998) for Castaic and Silverwood Lake data; Miller (1999) for Los Angeles Reservoir data; Caskey (1999) for San Andreas and Crystal Springs Reservoir data; Sweetwater Authority (1999) and Byard and Giroux (1999) for Sweetwater Reservoir.

Summary Discussion of Research

UCD researchers spoke with representatives from the Los Angeles Department of Water and Power (Los Angeles Reservoir), Metropolitan Water District of Southern California (Castaic Lake, Silverwood Lake), and San Francisco Department of Water (San Andreas, Crystal Springs). In general, reservoir representatives did not express concern about contamination from motor vehicle emissions; their biggest concern appears to be disinfection by-products [e.g., trihalomethanes (THMs)].

Most of the agencies interviewed do not test their source water for VOCs. The Los Angeles Department of Water and Power tested the Los Angeles Reservoir for MTBE intermittently between 1996 and 1998. All samples were "not detect" (ND) at a detection limit (DL) of 5 ug/L (Miller, 1999).

Castaic and Silverwood Lake Discussion

In 1997, the Metropolitan Water District of Southern California tested their source water for gasoline hydrocarbons to determine the impact of recreational activities on water quality. Two of the reservoirs tested are near highways. Castaic Lake, which is east of Interstate-5, and Silverwood Lake, which is east of Highway 138, were tested for MTBE. Motorized water recreation is allowed at both lakes year round.

Castaic Lake

In the summer months (April through September) the lake is thermally stratified and recreational use is high. The MTBE concentrations ranged from 2 to 29 ug/L in the epilimnion (upper layer of the lake). The concentrations ranged from ND to 2.6 ug/L in the hypolimnion (lower depth of lake). During the winter (when no stratification occurs and recreational activity is limited), the values ranged from ND to 3.8 ug/L. The majority of the MTBE detected was due to recreational activities on the lake, especially vehicles with two-stroke engines (e.g., jet skis). (Metropolitan Water District, 1998).

Silverwood Lake

Silverwood Lake usually has high levels of aquatic recreation. During the summer recreational period (March through September), the MTBE concentrations in the epilimnion ranged from 1.8 to 6.9 ug/L and from 2.2 to 4.1 ug/L in the hypolimnion. In the winter, when the lake is destratified, the values ranged from ND to 1.1 ug/L. Very low levels of Benzene, Toluene, Ethylbenzene, and Xylene (BTEX) compounds were also detected near the lake surface throughout the sampling period. (In general, BTEX compounds originate from petroleum sources.) These compounds volatilize quickly, so they were not considered to be a persistent problem in the lake (Metropolitan Water District, 1998).

In both lakes, the epilimnion concentrations were higher than the hypolimnion concentrations during the summer. This was due to the development of a thermocline, which essentially isolated the upper layers of the lakes from the lower layers, and the high recreational activity. In the fall, the lakes become destratified, leading to mixing of the water from the hypolimnion and epilimnion. The recreational activity also decreases, leading to the lower concentrations found during the winter months (Metropolitan Water District, 1998).

The current action level for MTBE in California is 13 ug/L, and the secondary MCL is 5 ug/L (California Department of Health Services, 1999). Thus, even if the MTBE concentrations in Castaic and Silverwood Lakes in the winter months are due solely to atmospheric deposition, the levels are still below California water quality standards. The low observed levels of BTEX compounds in the lakes is not surprising, since MTBE tends to be more persistent in water than other petroleum hydrocarbons. MTBE is more soluble than most gasoline constituents and does not volatilize or biodegrade as quickly (Office of Science and Technology, 1997).

Appendix E References

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